Touch&Tell: A game-based tool for learning to use the PHANToM

Eric Acosta, Bharti Temkin PhD
Department. of Computer Science, Texas Tech University
Lubbock, TX 79409
Bharti.Temkin@coe.ttu.edu

Abstract

We have developed a game, Touch&Tell, with the objective of teaching how to use the PHANToM. The game starts with simple 3D shapes and leads to progressively more complex 3D objects, including anatomical structures. The purpose is to overcome some of the problems encountered by inexperienced users, such as excessively large hand movements and loss of the object contact, and to increase the user's sensitivity to computer generated sense of touch. Visual and audio cues are initially included in order to help locate and stay in contact with the object; the cues can be removed as the skill improves.

The Touch&Tell game can be also used to collect data that elucidates decomposition of the sense of touch into sensory components. To this purpose the 3D object can be made invisible in order to help identify the effects of the visual component of haptics. Haptic skills can be monitored and recorded and progress evaluated for different levels of complexity. This makes it also possible to quantify the effectiveness of point-based haptic devices.

1. Introduction

Haptic sense, based on distributed and kinesthetic receptors, provides information about objects and surfaces being touched [1,2]. The sense of touch is a complex phenomenon involving many senses and the perceived sense of touch is subjective and dependent on physiological and psychological factors. For example, human psychophysical experiments have shown that both haptic and visual systems can create biases in virtual environments when used alone, but compensate for each other when used jointly [3]. Visual information can alter the haptic perception of spatial properties such as size, location, and shape [4]. Humans rely more on the visual than kinesthetic cues when the visual information conflicts with the haptic information for both spatial and stiffness information [3,5].

In real life, familiar objects can usually be identified haptically (without vision) with virtually no error within a period of 1-2 seconds [1]. Object exploration tends to begin with general-purpose procedures that provide coarse information about the object and lead to specialized procedures to look for distinctive features of the unknown object [1]. Simplifying the haptic stimuli to a point requires more exploration time to acquire a complex object's feature information.

Given the complexity of the human haptic sensory system, simulating touch in a virtual environment is likely to be difficult. During haptic application demonstrations, new users struggle to learn the use of haptic device and consequently have harder time performing specific application tasks. Touch&Tell was developed to teach the use of the device first, thus preparing the user for more complex application tasks.

2. Touch&Tell

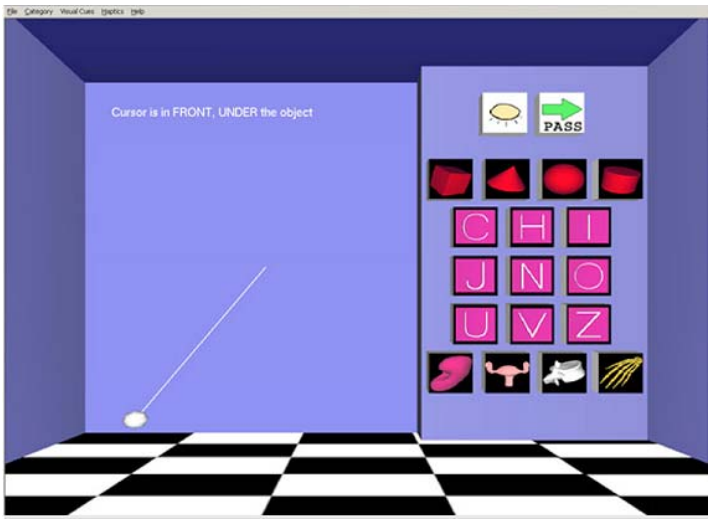

Figure 1. Touch & Tell game.

Initially, the user is shown how to move the haptic device to touch some simple 3D objects. After gaining some experience, the user is allowed to explore an object that is not displayed graphically. Separating the haptic and visual component requires the user to rely on the sense of touch to identify the object in question.

The device is used to touch an extendable library of objects, which is broken down into three groups of increasing complexity. These groups consist of solid geometric shapes, engraved alphabet blocks, and anatomical structures, Figure 1. As users explore the hidden object, they look for key characteristics that can be used for identification. For example, a cylinder would be identified if the object had a curved side and a flat top and bottom. The identification process forces controlled device movements in order to search for object's characteristics and thus refines user's control of the device. The geometric shapes help in general discrimination, alphabet objects require fine discrimination, and anatomical structures require both general and fine discrimination. In order to be successful, the user has to develop a strategy for object recognition.

An image key, shown in Figure 1, is provided to the user as a visual reference to aid in identifying the hidden object. After identifying the object, the user can press the corresponding haptic button on the image key to identify the object. A correct answer causes a bell sound, displays the hidden object, and then brings up the next hidden object. An incorrect decision causes a buzzer to sound and allows the user to make another guess.

2.1 Visual and audio cues

Optional visual and audio cues are included to help locate and stay in contact with the hidden object. The first visual cue is a line directing the proxy's graphical representation towards the center of the object. The second visual cue is a directional indication that tells the user whether the cursor is in front, behind, above, below, left, and/or right of the object. The combinations of the cues work well to reduce the level of difficulty for locating the object.

Once contact with an object is made the cursor turns green and a sound is played. When contact is lost, the cursor returns to the initial white color and another sound is played. These cues help the user to stay in contact with the object.

2.2 Changing the level of difficulty

An experienced user can choose to manipulate the objects (e.g. rotate, translate, and scale) and work at a more difficult level without the cues. There are other variable modes such as where the object category is known/unknown and the object is hard/soft. Using combinations of the different modes allows for increasing/decreasing the difficulty level of the task. For example, knowing the object's category reduces the number of possible choices and decreasing the stiffness of the object causes surface details to become less apparent. Other modes can be incorporated as needed for different experiments.

2.3 Data collection

In order to keep track of who is playing the game, the user must log in. All of the user's guesses are logged with a timestamp to determine the number of errors that occurred and the amount of time taken while identifying the unknown object. Two different timings are recorded. The first time is how long it takes to locate the object and the second is how long it takes to identify the object after the initial contact. Separation of these two times allows for a more accurate reading of how long the user actually explores the object in order to identify it. Touch&Tell also records contact information to keep track of the number of times the user gained/lost contact with the object. This helps in determining the ease of following the surface of the 3D object. Changes in strategy and user's difficulty level are also recorded. Based on a set of weighted parameters, the user's achieved level is calculated and stored.

3. Discussion

Although Touch&Tell is discussed in this paper as a tool for instructing users how to use the Phantom, it has many more potential applications. Touch&Tell can be a haptic research tool. Through various experiments, researchers trying to understand what roles the physiological and psychological factors (including vision) play for the sense of touch would benefit from this game. Other experiments, such as one performed by other researchers [6,7] to measure the Just Noticeable difference (JND) for force feedback, can be carried out. Researchers interested in the finer surface features [8] may be able to run experiments and see how effective the fine surface features are for identifying the objects. Experiments with Touch&Tell are expected to quantify how effective the sense of touch through a point-based device is for identifying 3D objects. This type of study will be beneficial for applications for visually impaired users.

4. Conclusions

Exploring a 3D environment with a point-based haptic device causes problems for new users. The Touch&Tell game teaches how to use the Phantom and how to control device movements in order to identify hidden objects by touch. Users utilize both general and fine discrimination in order to locate key characteristics of hidden objects for identification. This fun and challenging game is working as an effective tool to introduce haptics to new users.

Touch&Tell's data collection capabilities also make it possible to use it as a haptic research tool. Depending on the specific aim, Touch&Tell can be tailored to record different types of information.

A version of Touch&Tell called "ifeelit" is displayed as an exhibit in the Future Technology Center that Telecom Italia has created in Venice Italy.

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